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RESEARCH & CONSULTING

Microturbine Early Adopters: Where, When, Why?

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Our Microturbine Multi-Client Study:

- Spanned early market emergence of MTs – 2000 to 2002. Early interviewees re-visited
- 52 in-depth interviews with microturbine users in Europe and North America
- Included all commercial MT manufacturers
- 229 microturbines used by the interviewees
- 21 CHP, 4 CCHP and 27 power only applications amongst interviewees
- The most interesting trends were profiled in 5 detailed case studies

Key Findings of our Research...

Microturbines are making it!

- Microturbines are a successful new technology – though still a niche business
- Earlier interviews were all pilots; later were mostly commercial ventures
- Majority interviewed had a positive view of their microturbine experience
- Early units had some reliability problems; but predicted MT life now seems likely based on later performance
- Fuel gas compressors are still a life-limiting component in most designs

Key Findings, cont'd

- Low NOx designs are central to designs, and a key to their success
- Exhaust heat use (CHP) is an important value stream for MTs – offsets low efficiency
- Low / no cost "recovery" fuels are also a strong market
- Accordingly, applications are primarily prime power
- Low awareness of microturbines and CHP in North America is likely limiting penetration

Microturbines Today

- Around 3,000 units shipped
- Cost ~$1000/kW
- Have CHP integrated or as easy option
- 2nd generation pushing beyond 100 kW
- Can run off biogas, natural gas, liquid fuels
- Electric efficiencies 27%-31% (gross)
- <25 ppm NOx (some < 9 ppm)

The Microturbine Industry

5 major developers:

- *Capstone:* >80% market share; 30 & 60 kW units with multiple fuel options. Air bearings… By far most experience. 2400 units shipped*
- *Bowman:* 80 kW unit, designed for CHP applications; strong in Europe. 125 units shipped*
- *Ingersoll Rand:* 70 kW has really different design than others. Also has integrated CHP. Recently announced 250 kW MT. 80 units shipped*
- *Turbec:* 100 kW unit with integrated CHP and highest efficiency (30%). 150 units shipped*
- *Elliot:* Manufacture Bowman MT "core". Multiple fuel options. 125 units shipped*

***(All numbers as of 11/02)**

User Experiences

Good, bad or ugly: What made a difference?

1. Reliability
2. Manufacturer responsiveness to problems
3. Clear up-front expectations
4. A champion in the organization, at the site
5. Heat recovery
6. Interconnection Ease
7. Grants
8. Stable gas costs

Some ESCOS are applying them well

- Mariah Energy
  - ESCO out of Calgary, Canada
  - Owns and operated microturbines, generally in CHP mode
  - 20 projects using 30-kW and 60-kW Capstone units
- ENEL (Italy)
  - Building an ESCO CHP business with microturbines and reciprocating engines

Four Great Microturbine Applications

These applications were chosen for detailed case studies, based on interviews:

- Direct Use of Exhaust
  - 3 Interviews, 4 other installations studied – 56 units
- Combined Cooling and Power
  - 2 Interviews, 4 other installations studied – 38 units
- Biogas
  - 10 Interviews – 60 units
- Resource Recovery
  - 5 Interviews, 2 other installations studied ~ 118 units

Direct Use of Exhaust

- Low NOx enables direct firing into greenhouses
- Other applications include brick drying; combustion preheating; laundry; sludge drying; textile and polymer drying; curing concrete blocks; curing paints, etc.

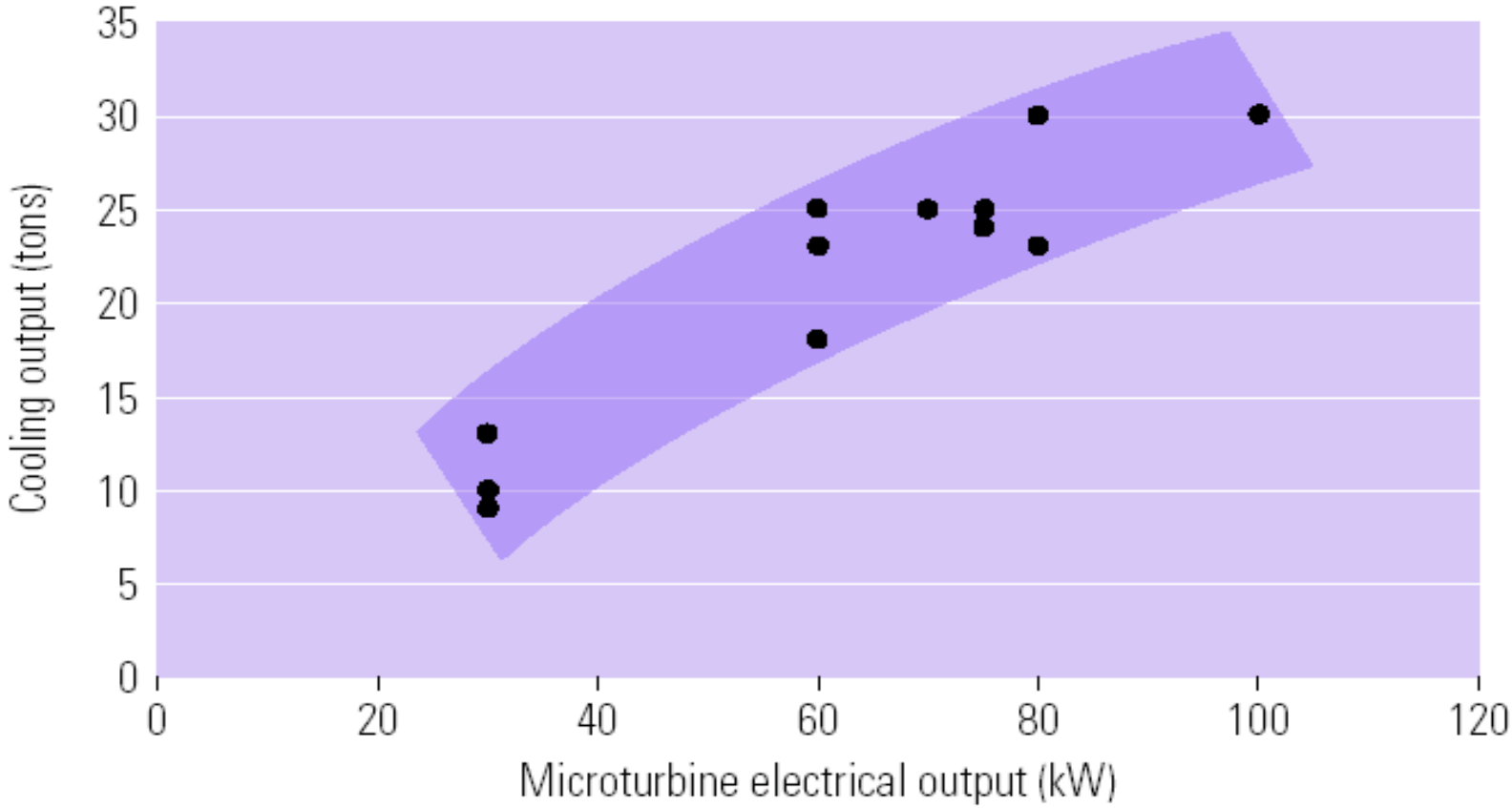
Courtesy Bowman Power Systems

Combined Cooling and Power

- High temperature exhaust allows double-effect absorption chilling (though most current applications do not capitalize on this)
- Can extend summer running hours
- Co-incidence of electric and cooling loads in hot climates

Courtesy Bowman Power Systems

How Much Cooling?



Biogas

- ~230 units running on biogas
- Able to use low methane content fuel
- Well suited for smaller sites
- New standardized gas processing system from Capstone
  - Simpler, more compact, more effective
- Capstone leads; Turbec, Ingersoll-Rand gaining experience

Biogas

Courtesy Capstone Turbine Corp.

- Siloxanes have been a problem for biogas-fueled microturbines
- Typically siloxane is filtered out – adding substantial cost
- Many recips operate without filtration – a claimed advantage – but we see problems for them as well

Resource Recovery

- Large number of smaller remote oil and gas sites – many need modest power
- Flaring of well gas is wasteful and not permitted in some areas - but small amounts of gas produced is usually not worth selling
- Microturbines' ability to use "free" gas with limited cleanup is economic driver
- Reliability is key – large opportunity if MT's can improve on recips now used at small sites
- Relative portability of MTs is also advantageous
- Many sites can use exhaust heat as well

Likely Futures for Microturbines

- Higher capacity units
- Goal of 40% electric efficiency (DOE Advanced MT)
- Cost reduction – especially in installation and transaction costs
- Wider fuel flexibility
- Capstone partnership with United Technology.
- Fuel cell – microturbine hybrid demonstrations
- Watch General Electric!

Summary

- Microturbines have emerged at a difficult time in the energy industry
- Bar Honeywell, all have survived – without *major* technical problems
- Major challenge is to go beyond early adopters market
- A number of unique attributes compared to reciprocating engines

Need More Information?

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